Antimicrobial copper surfaces

Copper touch surfaces in the clinical setting effectively reduce infection rates and save lives

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"It is now time for the clinical staff to be involved in the design of all hospitals before they are built"

In July 2014 the Prime Minister David Cameron called on global action to tackle the threat of resistance to antibiotics echoing the mounting voices of microbiologists and infection prevention teams nationwide.

Growing numbers of bacterial and viral infections are resistant to antimicrobial drugs, but no new classes of antibiotics have come onto the market for more than 25 years. About 25,000 people die each year in Europe alone from infections resistant to antibiotics. The World Health Organisation (WHO) has described this as one of the most significant global risks facing modern medicine.

The Prime Minister wants Britain to lead the way in exploring new ways to battle against antimicrobial resistant infections and has appointed Jim O'Neill to undertake a wide reaching independent review. This is supported by Professor Dame Sally Davies Chief Medical Officer in England and Dr Margaret Chan, Director General WHO.

Healthcare-associated infections (HCAIs) are infections resulting from medical care or treatment that were not present at the time of admission but were acquired in a medical facility, even if they only manifest at a later stage, once the patient has been discharged.[1] Sources of transmission can be endogenous (naturally occurring microorganisms in the patient's body that become invasive or contaminate sterile sites within the facility) or external, which includes transmission by healthcare workers, medical equipment and the environment. HCAIs are a major concern in intensive care units (ICUs) and the use of devices such as catheters and ventilators is associated with higher frequencies of infection.[2]

HCAIs constitute undoubtedly a significant burden worldwide, with higher infection prevalence in low- and middle-income countries.[3] In the US, approximately 1 in 25 will acquire a nosocomial infection and about 11.5% of those patients will subsequently die from that infection, which translates into the death of 205 patients every day.[4] In 2011, the prevalence of HCAIs averaged 5.7% of all hospitalisations and 19.5% of admissions to the ICU in the EU.[3] These rates mirror those found in England within the National Health Service, where 6.4% of all patients admitted to hospital without a pre-existing infection present with an HCAI; the infection rate that particular year was more than three times higher in the ICU, with 23.4% of adults infected.[5] However, some countries in the EU report infection prevalences of up to 51% in the ICU, of which the majority is an HCAI. Overall, in Europe alone over 4.1 million patients eventually acquire infections upon admission every year, resulting in 16 million extra days in hospital and an additional €7 billion in direct costs. It is estimated that 37,000 deaths are directly caused by HCAIs, which contribute to an additional 110,000 deaths.[3]

About 80% of nosocomial pathogens are spread through dry inanimate surfaces,[6] where they can persist for months.[7] Routine cleaning and sanitising procedures with regular detergents and antimicrobial agents, when properly implemented, are not sufficient to prevent infection of inert hard surfaces and recontamination.[8] Moreover, studies have shown that approximately 75% of healthcare workers do not wash their hands frequently enough to prevent cross transmission of pathogens.[9] This is particularly concerning since it is possible to transfer a pathogen such as Norovirus to five different surfaces through touch, which in turn places patients and healthcare workers who touch them at risk of becoming infected, perpetuating the transmission cycle.[10]

The most common pathogen in the general patient population HCAIs is *Staphylococcus aureus*, whereas *Acinetobacter* spp. is predominant in high risk patients.[11] Among HCAIs associated with multidrug-resistant pathogenic agents, methicillin-resistant *S. aureus* (MRSA) is the most prevalent strain. Other strains include vancomycin-resistant *Enterococcus faecium* (VRE), carbapenem-resistant P*seudomonas aeruginosa*, extended-spectrum cephalosporin-resistant *Klebsiella pneumoniae* and *Escherichia coli*, and carbapenem-resistant *A. baumannii, K. pneumoniae* and *E. coli.*[12]

Several stewardship strategies have been introduced at the institutional level in an attempt to reduce transmission of these pathogens and curb resistance development.[13] These comprise training and education of healthcare professionals for improved hand hygiene and adherence to infection prevention practices during insertion and care for medical devices, improved surface cleaning and disinfection and use of 'no-touch' automated room disinfection systems (that is, devices that produce ultraviolet light or hydrogen peroxide).[14]

Copper touch surfaces have recently emerged as an additional infection prevention measure in national surveillance and antibiotic control programmes, but they are not a substitute for regular hygiene and cleaning procedures. Antimicrobial copper surfaces include other metals such as brass and bronze to form copper alloys; over 450 alloys have been registered by the US Environmental Protection Agency against six strains of bacteria, including *S. aureus*, *E. coli*, *P. aeruginosa*, *Enterobacter aerogenes*, MRSA and VRE. Copper-containing surfaces are available in a wide range of colours, forms and finishes and can be applied to any area highly exposed to pathogens. They are durable, resistant and recyclable, and do not require additional or expensive cleaning methods or any kind of training and supervision. Moreover, they do not present the compliance issues associated with conventional hand hygiene and barrier precautions.

Antimicrobial properties of copper surfaces

Substantial *in vitro* testing has been performed in accordance with US Environmental Protection Agency-approved protocols. The viability of MRSA on copper surface C197 at room temperature is practically reduced to zero within 90 minutes of application of an inoculum of approximately 10 million colony-forming units (CFUs) under "wet" contamination conditions (for example, sneeze, splash). A more rapid effect is obtained in a dry touch simulation, with an elimination time of 45 minutes for pure copper surfaces inoculated with ten million CFUs at 22°C. A complete kill is achieved within six hours at a temperature of 4°C.[15] A recontamination test, consisting of eight MRSA inoculations (approximately one million CFUs) every three hours over 24 hours showed sustained antimicrobial properties with copper surface C110 compared with a stainless steel surface, a material commonly used in healthcare environments owing to its anticorrosion properties.

Copper surfaces consistently show superior performance in eliminating MRSA versus silver iron-containing materials and stainless steel surfaces at 20°C and 50% of relative humidity, with virtually no bacteria remaining 75 minutes after microbial exposure.[16] Dry contamination tests with VRE showed even more rapid kill rates, with a 7-log reduction in 10 minutes.[17] These and other studies showed increased efficacy of contact killing ability in surfaces with higher copper content and tested at high temperatures and relative humidity.[18] Overall, copper alloys have demonstrated rapid and broad-spectrum biocidal activity against bacteria, including *Legionella pneumophila*, *Escherichia coli* and *Clostridium difficile* (both vegetative cells and resistant spores) and resistant strains such as MRSA and VRE, as well as yeasts (*Candida albicans*) and viruses (Influenza A and Norovirus).[18] Horizontal gene transfer is also prevented, which assumes particular relevance in acquired antibiotic resistance, often conferred via plasmids containing resistance and virulence genes.[19]

Unlike chemical antimicrobial agents, resistance to copper touch surfaces is unlikely to develop owing to their rapid bactericidal effect and multiple, non-specific mechanisms of action.[20] Copper ions are released from the surface and alter the integrity and permeability of the cell membrane, ultimately resulting in cell lysis. In parallel, oxidative stress induced by the production of highly reactive free radicals further causes cell damage, leading to lipid, protein and DNA degradation.[21]

Use of antimicrobial copper in the healthcare setting

Several independent clinical trials evaluating the effectiveness of copper in high risk touch surfaces have been completed. These surfaces include

those heavily touched by patients and healthcare professionals (for example, door handles and taps, counters and bins, toilets and grab rails) as well as those in contact with individuals from outside the facility (for example, visitor chairs). Different rooms and wards may show variable infection rates according to patient mobility and inflow of visitors, which influence the frequency of hand-surface contacts.[22,23]

In a study conducted at the Memorial Sloan Kettering Cancer Center, the Medical University of South Carolina and the Ralph H Johnson Veterans Administration Medical Center, six selected hospital surface components, namely bed rails, over bed tables, IV poles, nurse call buttons, chair arms and computer accessories, were upgraded to antimicrobial copper in eight rooms in the ICUs and samples were collected weekly for 21 months. The investigators observed a reduction in environmental bioburden of 83% across the copper surfaces analysed (p<0.0001). Virtually no MRSA or VRE were detected on these surfaces; the combined MRSA and VRE burden was approximately 97% lower on copper versus plastic, wood, non-copper metal and painted surfaces.[24] Not surprisingly, a direct correlation between the environmental microbial burden and infection rates has been identified in this study, with 89% of HCAIs occurring in patients in rooms with a bioburden greater than 500 CFUs per 100 square centimetres. The infection rates in ICU rooms with and without copper surfaces were 3.4% and 8.43%, respectively, which corresponds to a reduction of 58.1% (p=0.013). By contrast, it was estimated that the implementation of effective routine hygiene practices would merely reduce the infection rate by 30%.[25]

"We should think of copper in prevention of infections in hospital as we think of speed bumps to prevent road accidents"

Economic impact of copper surfaces

Infection control through the use of self-sanitising copper touch surfaces not only contributes to lower mortality and morbidity rates in real world applications, but also reduces costs. The York Health Economics Consortium has developed a cost–benefit model to evaluate the return on investment of installing copper surfaces in newly built or renovated ICU units. The model was tested in the economic evaluation of the use of copper surfaces in a new 20-bed ICU facility in the UK and calculated that the cost of the new surfaces versus standard equipment, assuming that installation costs are similar, would offset in less than two months, considering an infection rate of 15% and a conservative infection risk reduction of 20%. This estimate corresponds to an average of 216 bed days and almost 160 sterling pounds saved per year. Moreover, cost savings associated with the technology will accrue from the reduction in number of occupied beds and from a better use of human resources just after the first months.[26]

The future of antimicrobial copper in infection control

A plethora of evidence supports the use of copper-containing, non-porous solid materials in healthcare facilities as an effective method to reduce environmental contamination of high risk touch surfaces, contributing to a reduction in infection rates and at the same time circumventing bacterial resistance mechanisms, a main concern in infection control with antibiotics.

Naturally, healthcare policy has accompanied these advances in research, and self-sanitising copper materials are included in key industry guidelines in the UK such as EPIC3 (National Evidence-

Based Guidelines for Preventing Healthcare-Associated Infections in NHS Hospitals in England)[27] and those by the Scottish Health Technologies Group.[28] In North America, the ECRI Institute, the Agency for Healthcare Research and Quality and The Canadian Network for Environmental Scanning in Health also nominated antimicrobial copper as a promising technology.[29–31]

One of the other interesting areas for development is the use of copper impregnated materials – think of the future hospitals with all the clothing, curtains and bedding impregnated with these materials!

Significant financial losses as well as tremendous costs in human lives resulting from conventional non-antimicrobial materials acting as continuous sources of transmission in medical facilities highlight the need for different cost effective approaches to hospital infection control policies. The installation of copper surfaces in specific patient care areas can significantly contribute toward this goal. ✦

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